NUTRIENTS AND ALGAE

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- **Nutrients in Lakes**
  - **Canadian author:** Alice Dove, Water Quality Monitoring and Surveillance, Environment and Climate Change Canada
  - **US author:** Eric Osantowski, U.S.EPA GLNPO

- **Harmful Algal Blooms**
  - **Canadian author:** Susan Watson, Environment and Climate Change Canada
  - **US author:** Greg Boyer, State University of New York

- **Cladophora**
  - **Canadian authors:** David Depew, Environment Canada; Todd Howell, Ontario Ministry of Environment and Climate Change; Alice Dove, Water Quality Monitoring and Surveillance, Environment and Climate Change Canada; Veronique Hiriart-Baer, Environment and Climate Change Canada
  - **US author:** Harvey Bootsma, University of Wisconsin-Milwaukee

Nutrients in Lakes Assessment

SUB-INDICATOR	GREAT LAKES BASIN	LAKE SUPERIOR	LAKE HURON	LAKE MICHIGAN	LAKE ERIE	LAKE ONTARIO
Nutrients in Lakes	**Status:** Fair **Trend:** Deteriorating	**Status:** Good **Trend:** Unchanging	**Status:** Fair (below target) **Trend:** Deteriorating (further below target)	**Status:** Fair (below target) **Trend:** Deteriorating (further below target)	**Status:** Poor (above target) **Trend:** Deteriorating	**Status:** Fair (below target) **Trend:** Deteriorating (further below target)

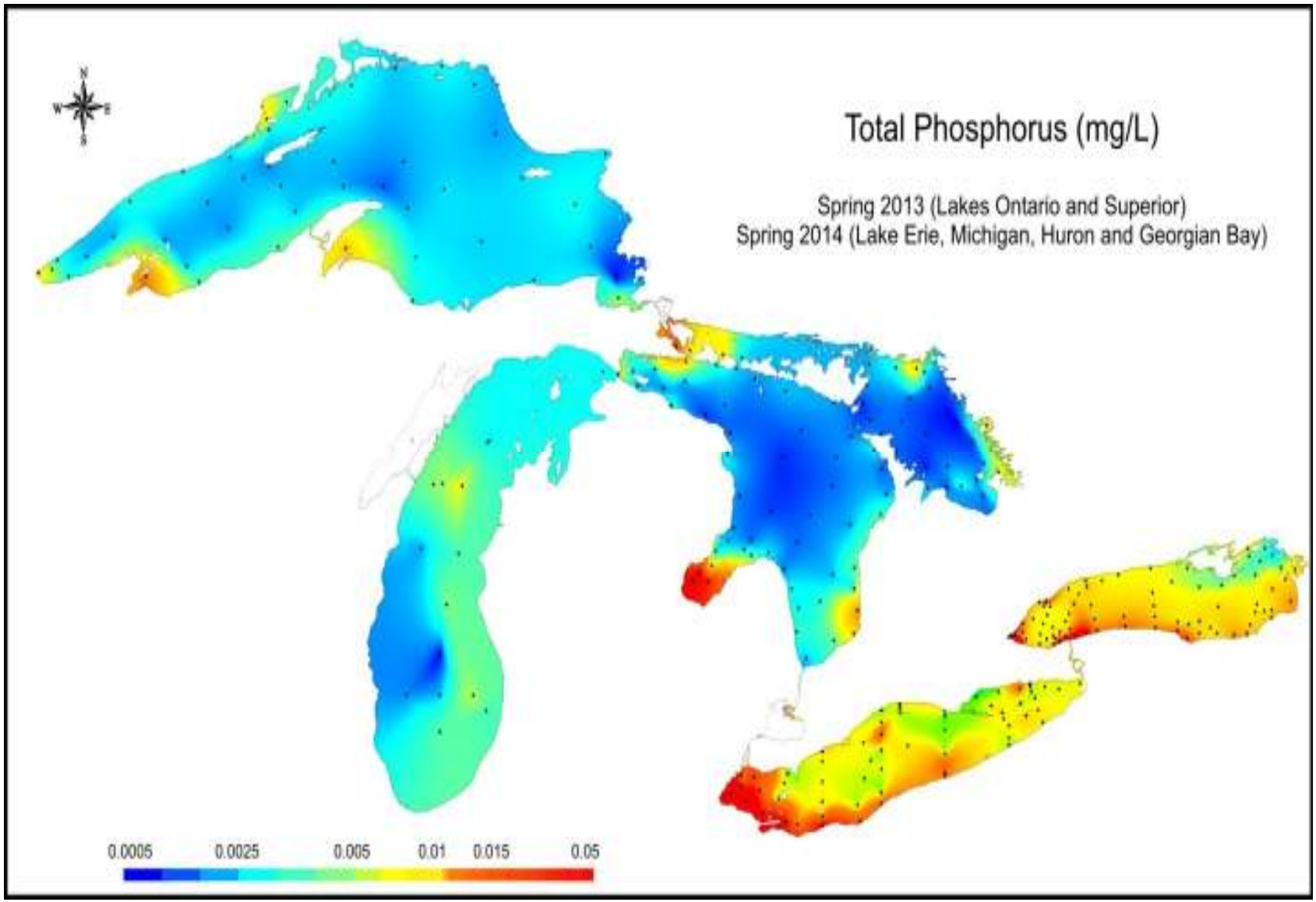

Figure 1. Spatial distribution of total phosphorus (ug/L) in the Great Lakes based on lake-wide cruises conducted during the spring 2013 and 2014 by Environment Canada and the United States Environmental Protection Agency

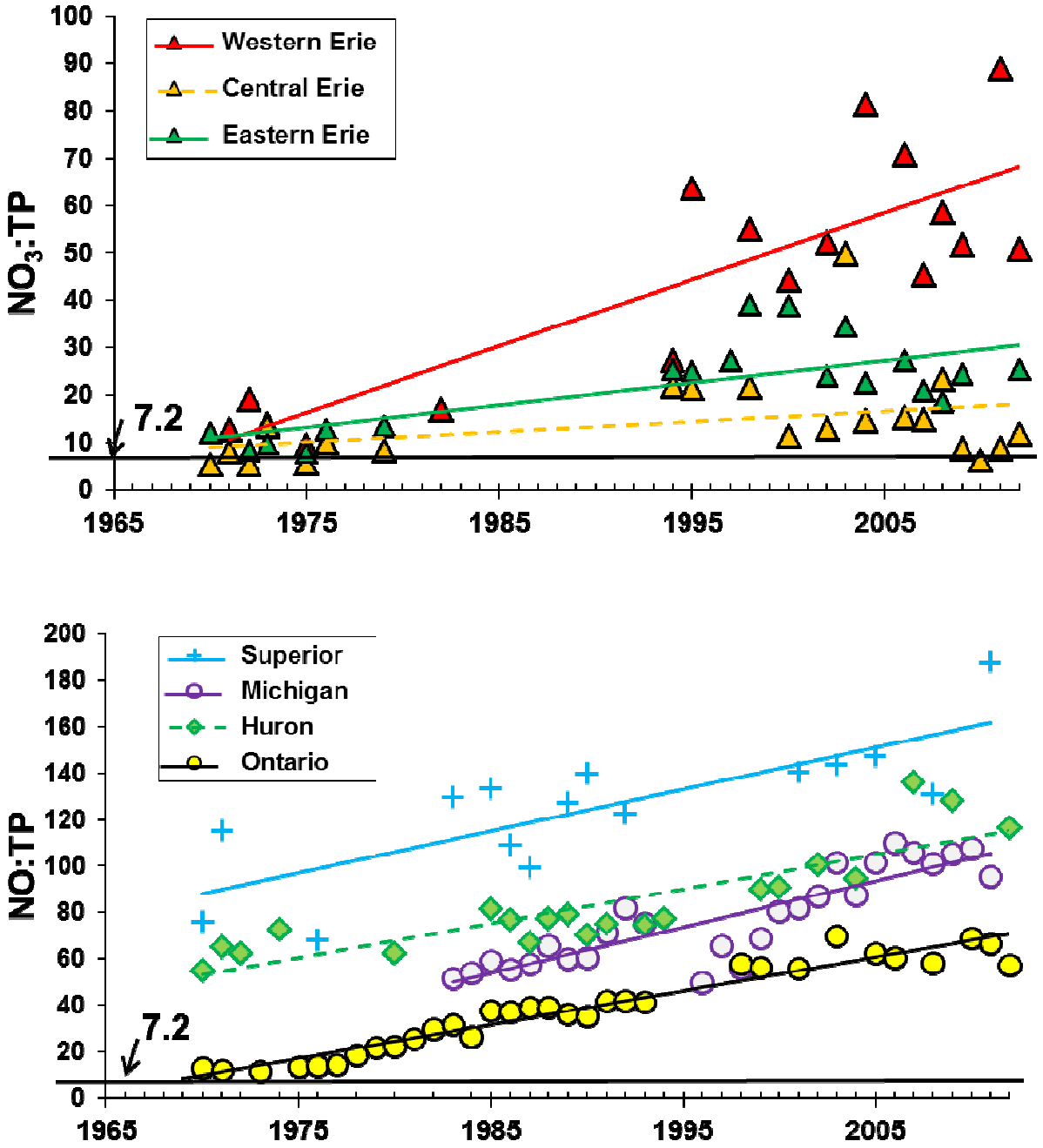

Figure 4. Trends of open lake, spring ratios of median NO_3:TP for the Great Lakes. The Redfield ratio of 7.2 mgN/mgP is superimposed as an estimate of the level above which lakes would tend to be phosphorus limited. Phosphorus limitation is beneficial because nitrogen limitation would favor potentially toxic blue-green algae (cyanobacteria).

Key Messages

- Offshore nutrient concentrations have declined over time and may be too low to support lake productivity
- Nearshore, eutrophic conditions, on the other hand, are persisting
- Dreissena mussels may be altering nutrient dynamics
- US and Canadian governments are developing revised water quality objectives for the lakes

Harmful Algal Blooms Assessment

SUB-INDICATOR	GREAT LAKES BASIN	LAKE SUPERIOR	LAKE HURON	LAKE MICHIGAN	LAKE ERIE	LAKE ONTARIO
Harmful Algal Blooms	**Status:** Fair **Trend:** Unchanging or Deteriorating	**Status:** Good **Trend:** Unchanging or Undetermined	**Status:** Fair **Trend:** Unchanging (offshore) and Deteriorating (nearshore)	**Status:** Fair **Trend:** Unchanging / Undetermined	**Status:** Poor **Trend:** Unchanging to Deteriorating	**Status:** Fair **Trend:** Unchanging (offshore) to Deteriorating/unchanging (nearshore)

Assessment

- Increase in severity of cyanobacteria blooms in the western basin of Lake Erie and nearshore areas
- Toxins vary greatly in their chemical properties, stability and toxicity
- Agencies are now testing for hepatotoxin mycrosystins
- Few samples from Lake Erie exceeded drinking water or recreational use guidelines
- Toxins can persist after a bloom has died and disappeared
- Erie and Ontario have monitoring programs; the other lakes do not

Figure 2. The maximum extent of the bloom on 6 September 2015 shown as a true colour image. The bloom was less concentrated at this time than in August. Raw data was obtained from NASA's Modis-Terra sensor.
http://www.glerl.noaa.gov/res/waterQuality/?targetTab=habs

Key Messages

- Increasing nutrients, climate change, and invasive species may lead to increased frequency, distribution and severity of algal blooms
- Harmful algal blooms are highly variable from year to year
- Surface blooms are recorded annually in the western Lake Erie basin
- A coordinated, interagency monitoring program needs to be continued and enhanced

Cladophora Assessment

SUB-INDICATOR	GREAT LAKES BASIN	LAKE SUPERIOR	LAKE HURON	LAKE MICHIGAN	LAKE ERIE	LAKE ONTARIO
Cladophora	**Status:** Fair **Trend:** Undetermined	**Status:** Good **Trend:** Unchanging	**Status:** Fair **Trend:** Undetermined	**Status:** Poor **Trend:** Undetermined	**Status:** Poor **Trend:** Undetermined	**Status:** Poor **Trend:** Undetermined

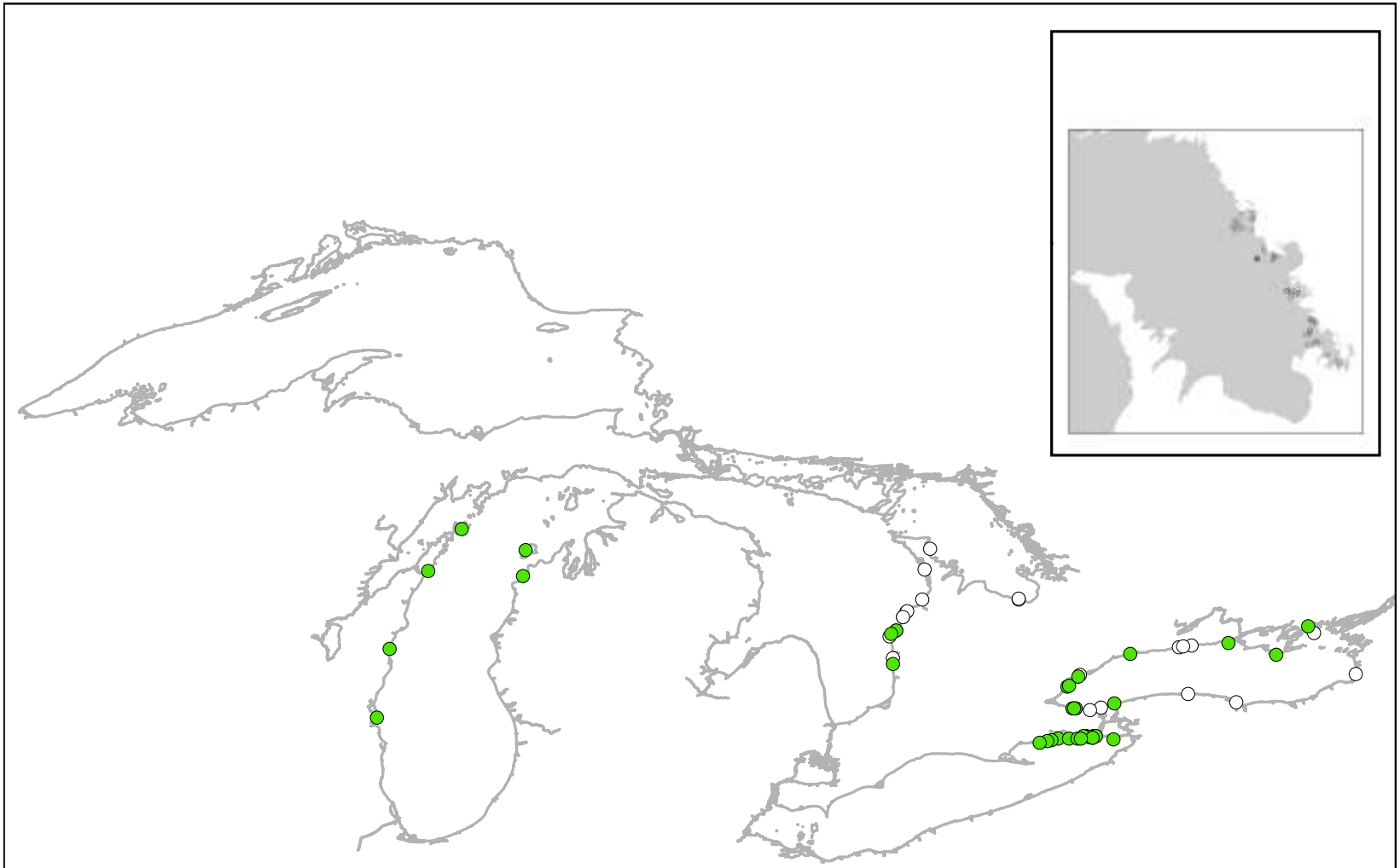

Figure 1. Locations within the Great Lakes where *Cladophora* has been reported since the year 2000. Empty circles indicate biomass below nuisance threshold of 50 g m^{-2} DW while filled circles indicate biomass above the nuisance threshold. Inset panel denotes higher resolution regions of eastern Georgian Bay where Ontario Ministry of Environment and Climate Change monitoring in 2014 took place.

Key Messages

- Drivers of Cladophora growth: temperature, irradiance, and soluble reactive phosphorus concentration
- Dreissenid mussels may play a role
- Presence of excessive biomass at a given location indicates potential for shore fouling
- Biomass is not necessarily correlated to production
- Regular monitoring programs are needed

Nutrients and Algae Sub-indicator Assessments

SUB-INDICATOR	GREAT LAKES BASIN	LAKE SUPERIOR	LAKE HURON	LAKE MICHIGAN	LAKE ERIE	LAKE ONTARIO
Nutrients in Lakes (open water)	**Status:** Fair **Trend:** Deteriorating	**Status:** Good **Trend:** Unchanging	**Status:** Fair (below target) **Trend:** Deteriorating (further below target)	**Status:** Fair (below target) **Trend:** Deteriorating (further below target)	**Status:** Poor (above target) **Trend:** Deteriorating	**Status:** Fair (below target) **Trend:** Deteriorating (further below target)
Harmful Algal Blooms	**Status:** Fair **Trend:** Unchanging or Deteriorating	**Status:** Good **Trend:** Unchanging or Undetermined	**Status:** Fair **Trend:** Unchanging (offshore) and Deteriorating (some nearshore regions)	**Status:** Fair **Trend:** Unchanging / Undetermined	**Status:** Poor **Trend:** Unchanging to Deteriorating	**Status:** Fair **Trend:** Unchanging (offshore) to Deteriorating / unchanging (nearshore)
Cladophora	**Status:** Fair **Trend:** Undetermined	**Status:** Good **Trend:** Unchanging	**Status:** Fair **Trend:** Undetermined	**Status:** Poor **Trend:** Undetermined	**Status:** Poor **Trend:** Undetermined	**Status:** Poor **Trend:** Undetermined